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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
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Objective lens and scanning device using such an objective lens

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Objective lens and scanning device using such an objective lens.

FIELD OF THE INVENTION

The present invention relates to an objective lens for scanning information carriers having transparent layers with different thickness.

The present invention also relates to a scanning device for scanning information carriers having transparent layers with different thickness.

The present invention is particularly relevant for an optical disc apparatus for reading and/or recording data from and/or to different optical discs, e.g. a CD/DVD/BD player and/or recorder.

BACKGROUND OF THE INVENTION

In the field of optical recording, increasing the capacity of the information carrier is the trend. The capacity of an information layer depends, inter alia, on the size of the spot formed by a radiation beam focussed on the information layer. The higher the numerical aperture of the radiation beam, the smaller the spot size. As a consequence, different types of information carriers have been developed or are under development, in order to increase the capacity of the information carrier. For example, a CD (Compact Disc) has been developed, which has a capacity of 700 megabytes, and is scanned by a radiation beam having a numerical aperture (NA) of 0.45. A DVD (Digital Video Disc) has then been developed, which has a capacity of 4.7 gigabytes, and is scanned by a radiation beam having a NA of 0.65. Right now, a BD (Blu-Ray Disc) is being developed, which has a capacity of about 25 gigabytes, and is scanned by a radiation beam having a NA of 0.85.

Furthermore, when the NA is increased, it is necessary to reduce the thickness of the transparent layer protecting the information layer, in order to reduce the influence of disc tilt on the quality of the radiation beam. For example, the thickness of the transparent layer of a CD is 1.2 millimetres, the thickness of the transparent layer of a CD is 0.6 millimetres and the thickness of the transparent layer of a BD is 0.1 millimetres.

A compatible player and/or recorder should be able to scan the different types of information carrier. United States Patent US 6,052,237 describes a scanning device capable of scanning two different types of information carriers, having different thickness of transparent layer. This scanning device comprises a radiation source and an objective lens having an outer annular part and a central part inside the annular part. The annular part has a numerical aperture higher than the numerical aperture of the central part.

This scanning device is capable of scanning a first information carrier having a first transparent layer with a first thickness and a second information carrier having a second transparent layer with a second thickness larger than the first thickness. The annular part introduces a first spherical aberration in the radiation beam compensating for passage of the radiation beam through the first transparent layer and the central part introduces a second spherical aberration in the radiation beam compensating for passage of the radiation beam through the second transparent layer.

When the second information carrier is scanned, the radiation beam passes through the central part and the second transparent layer, to be focused on a second information layer. When the first information carrier is scanned, the radiation beam passes through the combined area of the annular part and the central part and through the first transparent layer, to be focused on a first information layer.

In this scanning device, the spherical aberration introduced by the first transparent layer is compensated, because the correction of the central part of the objective lens for a thickness of the transparent layer different from the thickness of the transparent layer for which the annular part is corrected has only a relatively small influence.

This might be true when the NA of the annular part is 0.6 and the NA of the central part is 0.33, as stated in this patent. However, this is not true anymore when the NA of the annular part is increased, for example to 0.85. As a consequence, such a scanning device cannot be used for scanning, for example, a Blu-Ray Disc and a DVD. Actually, in order to use such an objective lens for scanning a BD and a DVD, the annular part should have a NA of 0.85. In order to reduce the influence of the central part on the radiation beam having a NA of 0.85, the central part should be as small as possible. Unfortunately, a small central part cannot be used, because the free working distance of the central part would be too small to cope with the thickness of the transparent layer of a DVD.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an objective lens and a scanning device for scanning different types of information carriers with increased numerical apertures.

To this end, the invention proposes an objective lens comprising at least an annular part having a first numerical aperture and a central part having a second numerical aperture, wherein the second numerical aperture is higher than the first numerical aperture.

At least a first information carrier having a first transparent layer with a first thickness and a second information carrier having a second transparent layer with a second thickness larger than the first thickness can be scanned by a scanning device implementing an objective lens in accordance with the invention. When scanning the first information carrier, a first radiation beam is focussed on a first information layer, by means of the central part of the objective lens. The first NA can be taken as high as desired, as a function of the information carriers intended to be scanned by the scanning device. For example, the first NA can be 0.85, in order to scan a BD Disc. When scanning the second information carrier, a second radiation beam is focussed on a second information layer, by means of the combined area of the annular part and the central part of the objective lens. Only the part of the radiation beam, which passes through the annular part of the objective lens, is focussed on the second information layer. However, when scanning the second information layer with the second numerical aperture, the central part of the second radiation beam might be missed without affecting the quality of the scanning, because the second numerical aperture is relatively low compared to the first numerical aperture. For example, the second numerical aperture is 0.65.

If, like in the prior art, the first numerical aperture were lower than the second numerical aperture, the quality of the scanning would be affected when scanning an information layer with a relatively high NA through the combined area of the annular part and the central part of the objective lens. Actually, a radiation beam having a high NA, such as 0.85, is very sensitive, and missing the central part of such a beam leads to a relatively bad scanning.

Advantageously, the objective lens comprises an optical axis and a cavity located around said optical axis, said cavity having a substantially cylindrical shape, the bottom of said cavity forming the central part of the objective lens.

Such an objective lens is particularly advantageous, as it might be relatively small. Actually, when a radius of the annular part is relatively small, the radius of the central part is even smaller. As a consequence, the free working distance of the central part is small, and might be smaller than the width of the objective lens in the direction of its optical axis. However, in such an objective lens having a cavity, the central part of the objective lens might be placed near the output surface of the objective lens. As a consequence, an information carrier with a relatively small thickness of the transparent layer might be scanned, even if the free working distance of the central part is small.

Furthermore, such an objective lens is relatively easy to manufacture, as it can be moulded. A mould might be manufactured, which mould has a profile suitable for producing the objective lens when an optical material, such as glass or

plastic, is introduced in the mould. Hence, a high quantity of objective lenses might be manufactured with a high accuracy by means of the same mould.

The invention also relates to a lens assembly comprising a first lens with an annular part having a first numerical aperture and a central part, and a second lens, the second lens and the central part of the first lens forming a two elements objective lens having a second numerical aperture, wherein the second numerical aperture is higher than the first numerical aperture.

Such a lens assembly advantageously replaces the objective lens as described hereinbefore. Instead of the central part of the objective lens, a two elements objective lens is used. This is particularly advantageous when the lens assembly is made from plastic, which has a low refractive index. Actually, in the objective lens as described hereinbefore, the curvature of the central part is high when the NA of the central part is high. This requires a relatively high accuracy during the manufacturing process, which is not required when a two elements objective lens is used.

The invention also relates to an optical scanning device for scanning at least a first type of information carrier having a first information layer and a first transparent layer of first thickness and a second type of information carrier having a second information layer and a second transparent layer of second thickness larger than the first thickness, said optical scanning device comprising means for generating at least a first and a second radiation beams, and an objective lens comprising at least an annular part having a first numerical aperture and a central part having a second numerical aperture higher than the first numerical aperture, wherein the first information layer is intended to be scanned by the first radiation beam through the central part of the objective lens and the first transparent layer, and the second information layer is intended to be scanned by the second radiation beam through the annular part of the objective lens and the second transparent layer.

The invention also relates to an optical scanning device for scanning at least a first type of information carrier having a first information layer and a first transparent layer of first thickness and a second type of information carrier having a second information layer and a second transparent layer of second thickness larger than the first thickness, said optical scanning device comprising means for generating at least a first and a second radiation beams, and a lens assembly comprising a first lens with an annular part having a first numerical aperture and a central part, and a second lens, the second lens and the central part of the first lens forming a two elements objective lens having a second numerical aperture higher than the first numerical aperture, wherein the first information layer is intended to be scanned by the first radiation beam through the two elements objective lens and

the first transparent layer, and the second information layer is intended to be scanned by the second radiation beam through the annular part of the first lens and the second transparent layer.

These and other aspects of the invention will be apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

- Fig. 1a and 1b show an objective lens in accordance with the invention;
- Fig. 2 shows another objective lens in accordance with the invention;
- Fig. 3a and 3b show a lens assembly in accordance with the invention;
- Fig. 4 shows a scanning device in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

An objective lens in accordance with the invention is depicted in Fig.1a and 1b. Such an objective lens 10 comprises an annular part 101 and a central part 102. On Fig.1b, the objective lens 10 is used for scanning a first information carrier 11 comprising an information layer 111 and a transparent layer 112. On Fig.1a, the objective lens 10 is used for scanning a second information carrier 12 comprising an information layer 121 and a transparent layer 122.

In the example described hereinafter, the first information carrier 11 is a BD scanned by a first radiation beam 13 and the second information carrier 12 is a DVD scanned by a second radiation beam 14. The first radiation beam 13 has a first wavelength, which is equal to 405 nanometres. The second radiation beam 14 has a second wavelength, which is equal to 650 nanometres. The thickness of the first transparent layer 112 is 0.1 millimetres and the thickness of the second transparent layer 122 is 0.6 millimetres. The radius of the annular part 101 is 1.8 millimetres and the radius of the central part 102 is 0.5 millimetres. The NA of the annular part 101 is 0.65 and the NA of the central part 102 is 0.85. The focal length of the annular part 101 is 2.75 millimetres and the focal length of the central part 102 is 0.58 millimetres.

When the first information layer 111 is scanned, the first radiation beam 13, which is a parallel beam having a diameter substantially equal to the diameter of the central part 102, passes through the central part 102 and is focussed on the first information layer 111, through the first transparent layer 112.

The objective lens 10 might be moved along its optical axis in order to obtain an accurate focus. As the central part has a relatively small radius and a relatively high NA, the free working distance of the central part 102, which represents the maximum possible distance between the output surface of the central part 102 and the surface of the transparent layer 112, is relatively small. In this example, the free working distance of the central part 102 is about 0.4 millimetres. However, according to the invention, this is not a problem, because the central part 102 of the objective lens 10 is used for scanning information carriers having a small thickness of transparent layer. As a consequence, the NA of the central part 102 might be high, for example higher than 0.7 or even higher than 0.8.

When the second information layer 121 is scanned, the second radiation beam 14, which is a parallel beam having a diameter substantially equal to the diameter of the annular part 101, passes through the combined area of the annular part 101 and the central part 102. Compared to the scanning of the first information layer 111, the objective lens 10 is moved along its optical axis in a direction opposed to the first information layer 111 when a second information layer is scanned. This is possible, because the free working distance of the annular part 101 of the objective lens 10 is relatively high, as the radius of the annular part 101 is high and the NA of the annular part 101 is low. The NA of the annular part 101 is preferably between 0.35 and 0.7, but might be higher if the NA of the central part 102 is even higher. For example, the NA of the central part 102 might be higher than 0.9, 1, 1.1 or 1.2. In these cases, the NA of the annular part 101 might be respectively 0.7, 0.8, 0.9 or 1 for example. Preferably, the NA of the annular part 101 is more than ten percent lower than the NA of the central part 102.

When the second information layer 121 is scanned, the outer part of the second radiation beam 14, corresponding to the part of the second radiation beam 14 passing through the annular part 101, is focussed on the second information layer 121. The central part of the second radiation beam 14, corresponding to the part of the second radiation beam 14 passing through the central part 102, is not focussed on the second information layer 121. As a consequence, this central part of the second radiation beam 14 is not used for scanning the second information layer 121. However, this does not affect the scanning, because the NA of the second radiation beam 14 is relatively small, so that the signal read or written to or from the second information layer 121 is not affected by the absence of a central part of the second radiation beam 14.

It is important to notice that the objective lens of Fig.1a and 1b might be used for scanning more than two different types of information carriers. For example, this objective lens might be used for scanning a CD. In order to scan a CD, the annular part 101 of the objective lens 10 is divided into a first annular area

having a NA equal to 0.45 and a second annular area having a NA equal to 0.6. The first annular area is located near the optical axis of the objective lens 10. Such an annular part 101 might be used for scanning a CD and a DVD, as explained in US 6,052,237, which does not apply to an annular part divided into two annular areas, but to a lens divided into two areas. As a consequence, such an objective lens might be used for scanning a CD, a DVD or a BD. Another objective lens according to the invention, which might be used for scanning a CD, a DVD or a BD, is depicted on Fig.2.

Fig. 2 shows another objective lens in accordance with the invention. Such an objective lens 20 comprises a first annular part 201, a second annular part 202 and a central part 203.

The radius r3 of the first annular part 201 is 1.8 millimetres, the radius r2 of the second annular part 202 is 1.2 millimetres and the radius r1 of the central part 203 is 0.5 millimetres. The NA of the first annular part 201 is 0.45, the NA of the second annular part 202 is 0.65 and the NA of the central part 203 is 0.85.

When a CD is scanned by means of the objective lens 20, a third radiation beam having a wavelength of 785 nanometres, and a radius substantially equal to r3, passes through the combined area of the first annular part 201, the second annular part 202 and the central part 203. Only the part of the third radiation beam passing through the first annular area 201 is focussed on an information layer of the CD. However, this does not affect the scanning, as explained hereinbefore, because the NA of the third radiation beam is low.

When a DVD is scanned by means of the objective lens 20, a second radiation beam having a wavelength of 650 nanometres, and a radius substantially equal to r2, passes through the combined area of the second annular part 202 and the central part 203. As explained on Fig.1a and 1b, the scanning is not affected by the fact that only the part of the second radiation beam passing through the second annular part 202 is used for the scanning.

When a BD is scanned by means of the objective lens 20, a first radiation beam having a wavelength of 405 nanometres, and a radius substantially equal to r1, passes through the central part 203 and is focussed on an information layer of the BD.

Fig. 3a and 3b show a lens assembly in accordance with the invention. Such a lens assembly comprises a first lens 30 comprising an annular part 301 and a central part 302, and a second lens 31. The central part 302 of the first lens 30 and the second lens 31 are combined in order to form a two elements objective lens. This two elements objective lens has a numerical aperture, which is equal to 0.85.

The annular part 301 of the first lens 30 has a numerical aperture, which is equal to 0.65.

When the first information layer 111 is scanned, the first radiation beam 13 passes through the two elements objective lens and is focussed on the first information layer 111, through the first transparent layer 112. When the second information layer 121 is scanned, the second radiation beam 14 passes through the combined area of the annular part 301 and the two elements objective lens.

As explained in the description of Fig.1a and 1b, the lens assembly of Fig.3a and 3b might be used for scanning more than two different types of information carrier.

Compared to the objective lens of Fig.1a and 1b, the lens assembly is easier to manufacture. Actually, manufacturing a single element objective lens having a high NA requires a high accuracy during the manufacturing process, which is not the case with a two elements objective lens, because the curvatures of the two elements might be lower than the curvature of a single element.

Fig. 4 shows a scanning device in accordance with the invention. Such an optical scanning device comprises a first radiation source 401 for producing a first radiation beam 403, a second radiation source 402 for producing a second radiation beam 404, a first beam splitter 405, a collimator lens 406, a second beam splitter 407, an objective lens 408, a servo lens 409 and detecting means 410. This optical device is intended for scanning an information carrier 411 comprising an information layer 412 and a transparent layer 413.

In the example described on Fig.4, the information carrier 411 is a DVD. The information layer 412 is scanned by the second radiation beam 404 produced by the second radiation source 402. The second radiation beam 404 has a second wavelength equal to 650 nanometres. The collimator lens 406 and the objective lens 408 focus the second radiation beam 404 on the information layer 412, through the transparent layer 413 having a thickness equal to 0.6 millimetres. The objective lens 408 is the objective lens 10 of Fig. 1a and 1b. Instead of the objective lens 10 of Fig. 1a and 1b, the lens assembly of Fig 3a and 3b might be used as objective lens 408.

When another information layer is to be scanned, such as a BD disc, this information layer is scanned by the first radiation beam 403 produced by the first radiation source 401. The first radiation beam 403 has a first wavelength equal to 405 nanometres. In order to achieve the scanning of a BD disc, the objective lens is moved in the direction of the information carrier 411, by means of an actuator, not represented on Fig.4. The scanning device is designed so that the diameter of the second radiation beam 404 is substantially equal to the diameter of the annular

part of the objective lens 408 and the diameter of the first radiation beam 403 is substantially equal to the diameter of the central part of the objective lens 408.

The second radiation beam 404, reflected by the information layer 412, is transformed to a parallel beam by the objective lens 408, and then reaches the servo lens 409, by means of the second beam splitter 407. This reflected beam then reaches the detecting means 410, which, for example, might detect a focus error signal. This also applies to the first radiation beam 403, when a BD disc is scanned.

It is important to notice that the scanning device of Fig.4 might be used for scanning more than two different types of information carriers. For example, a third radiation source might be provided in the optical scanning device, said third source being able to produce a third radiation beam having a third wavelength equal to 785 nanometres. This third radiation beam might be used for scanning a CD. In this case, the objective lens 20 of Fig.2 might be used as the objective lens 408.

Any reference sign in the following claims should not be construed as limiting the claim. It will be obvious that the use of the verb "to comprise" and its conjugations does not exclude the presence of any other elements besides those defined in any claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

Claims

1. An optical scanning device for scanning at least a first type of information carrier (11) having a first information layer (111) and a first transparent layer (112) of first thickness and a second type of information carrier (12, 411) having a second information layer (121, 412) and a second transparent layer (122, 413) of second thickness larger than the first thickness, said optical scanning device comprising means (401, 402) for generating at least a first and a second radiation beams (403, 404), and an objective lens (10, 20, 408) comprising at least an annular part (101, 201) having a first numerical aperture, and a central part (102, 203) having a second numerical aperture higher than the first numerical aperture, wherein the first information layer is intended to be scanned by the first radiation beam through the central part of the objective lens and the first transparent layer, and the second information layer is intended to be scanned by the second radiation beam through the annular part of the objective lens and the second transparent layer.

2. An optical scanning device as claimed in Claim 1, wherein said objective lens comprises an optical axis and a cavity located around said optical axis, said cavity having a substantially cylindrical shape, the bottom of said cavity forming the central part of the objective lens.

3. An optical scanning device as claimed in Claim 1, wherein the second numerical aperture is higher than 0.7 and the first numerical aperture is more than ten per cent lower than the first numerical aperture.

4. An optical scanning device for scanning at least a first type of information carrier having a first information layer and a first transparent layer of first thickness and a second type of information carrier having a second information layer and a second transparent layer of second thickness larger than the first thickness, said optical scanning device comprising means for generating at least a first and a second radiation beams, and a lens assembly comprising a first lens (30) with an annular part (301) having a first numerical aperture and a central part (302), and a second lens (31), the second lens and the central part of the first lens forming a two elements objective lens having a second numerical aperture higher than the first numerical aperture, wherein the first information layer is intended to be scanned by the first radiation beam through the two elements objective lens and the first transparent layer, and the second information layer is intended to be

scanned by the second radiation beam through the annular part of the first lens and the second transparent layer.

5. An objective lens (10, 20) comprising at least an annular part (101, 201) having a first numerical aperture, and a central part (102, 203) having a second numerical aperture, wherein the second numerical aperture is higher than the first numerical aperture.

6. An objective lens as claimed in claim 5, said lens comprising an optical axis and a cavity located around said optical axis, said cavity having a substantially cylindrical shape, the bottom of said cavity forming the central part of the objective lens.

7. An objective lens as claimed in claim 5, wherein the second numerical aperture is higher than 0.7 and the first numerical aperture is more than ten per cent lower than the first numerical aperture.

8. An objective lens as claimed in claim 5, wherein the first numerical aperture is between 0.35 and 0.7 and the second numerical aperture is higher than 0.7.

9. An objective lens as claimed in claim 5, wherein the first numerical aperture is between 0.35 and 0.7 and the second numerical aperture is higher than 0.8.

10. A lens assembly comprising a first lens (30) with an annular part (301) having a first numerical aperture and a central part (302), and a second lens (31), the second lens and the central part of the first lens forming a two elements objective lens having a second numerical aperture, wherein the second numerical aperture is higher than the first numerical aperture.

Abstract

The invention relates to an objective lens and an optical device for scanning different information carriers having different cover layer thickness, with different numerical apertures. The objective lens (10, 20) comprises at least an annular part (101, 201) having a first numerical aperture and a central part (102, 203) having a second numerical aperture. The second numerical aperture is higher than the first numerical aperture.

Fig.1a and 1b

FIG. 1a

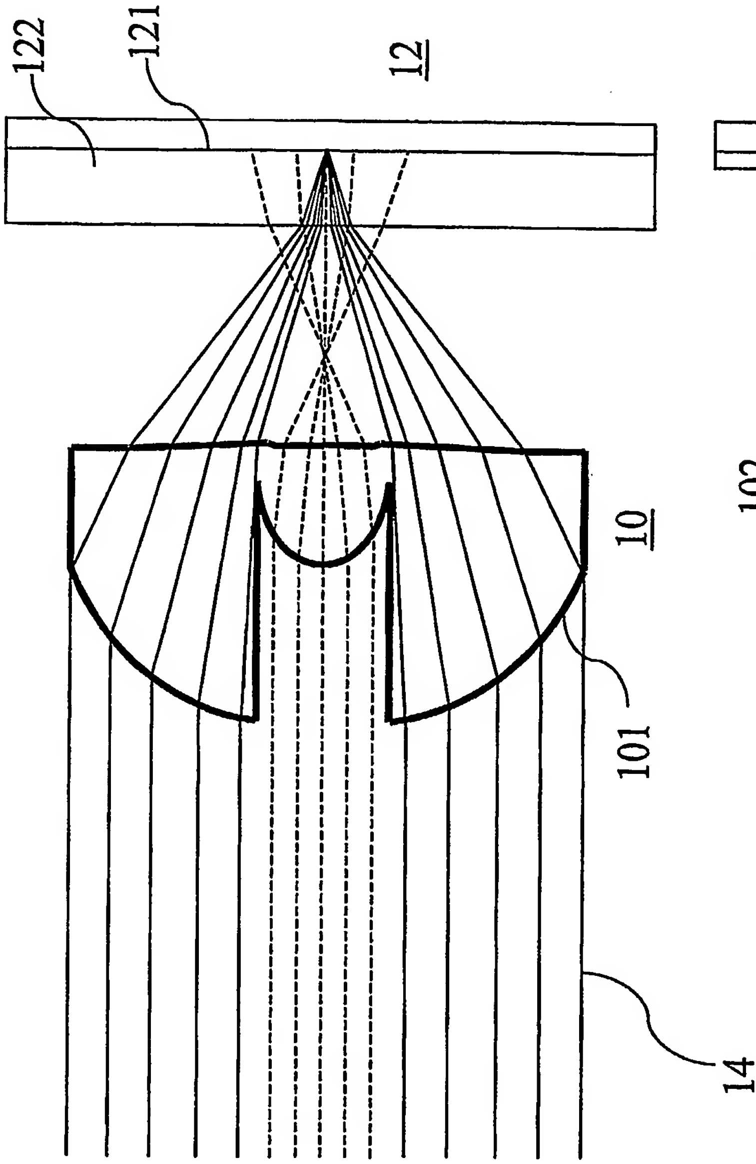


FIG. 1b

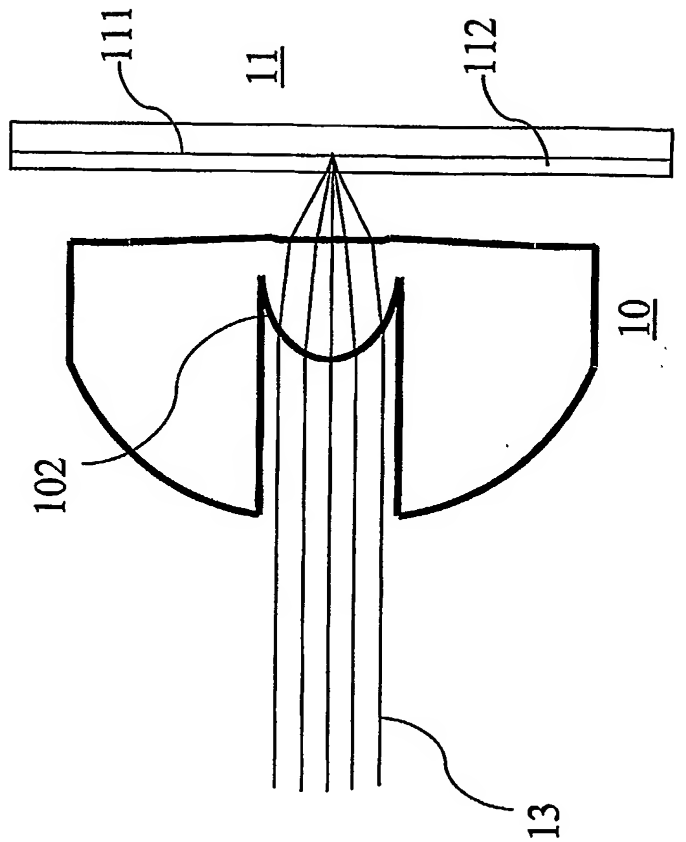


FIG. 2

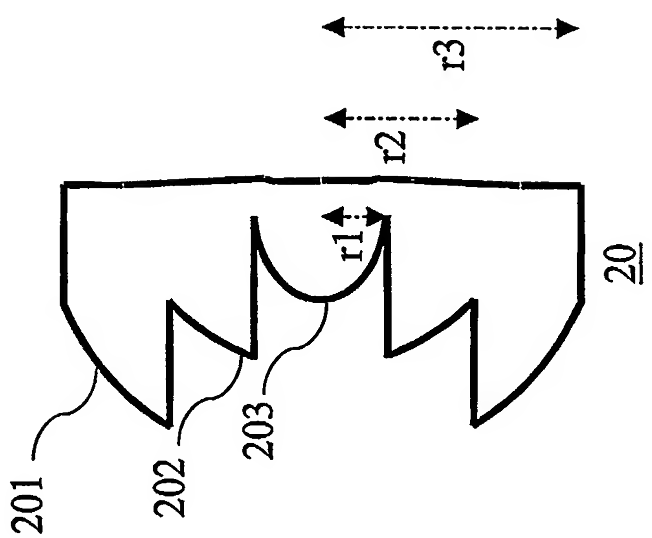


FIG. 3a

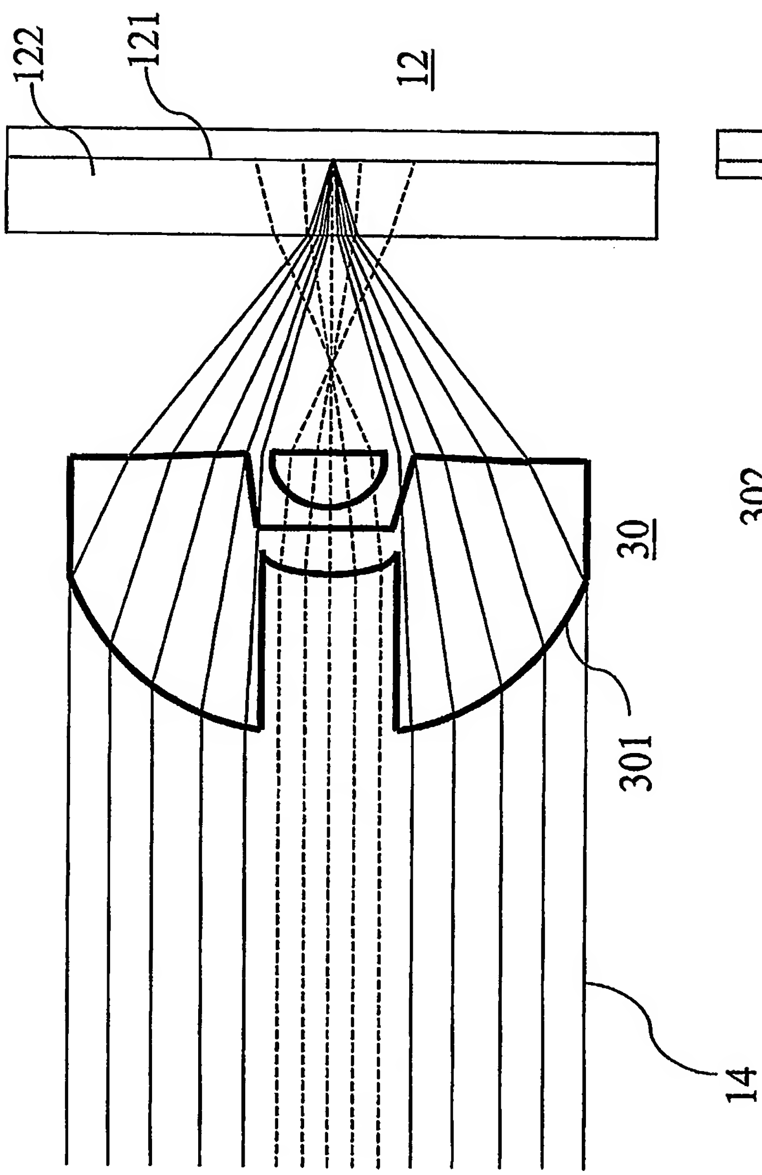
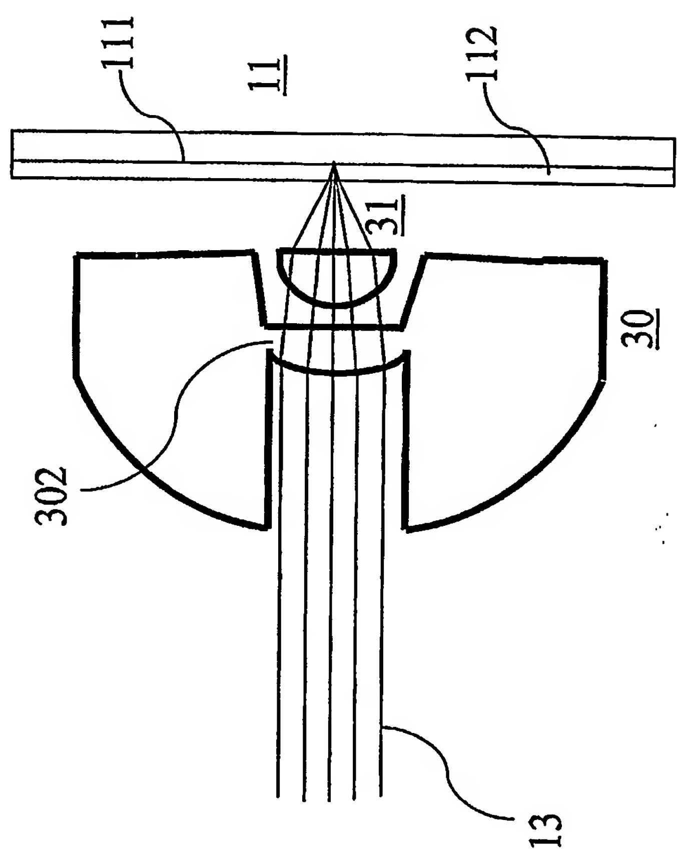


FIG. 3b



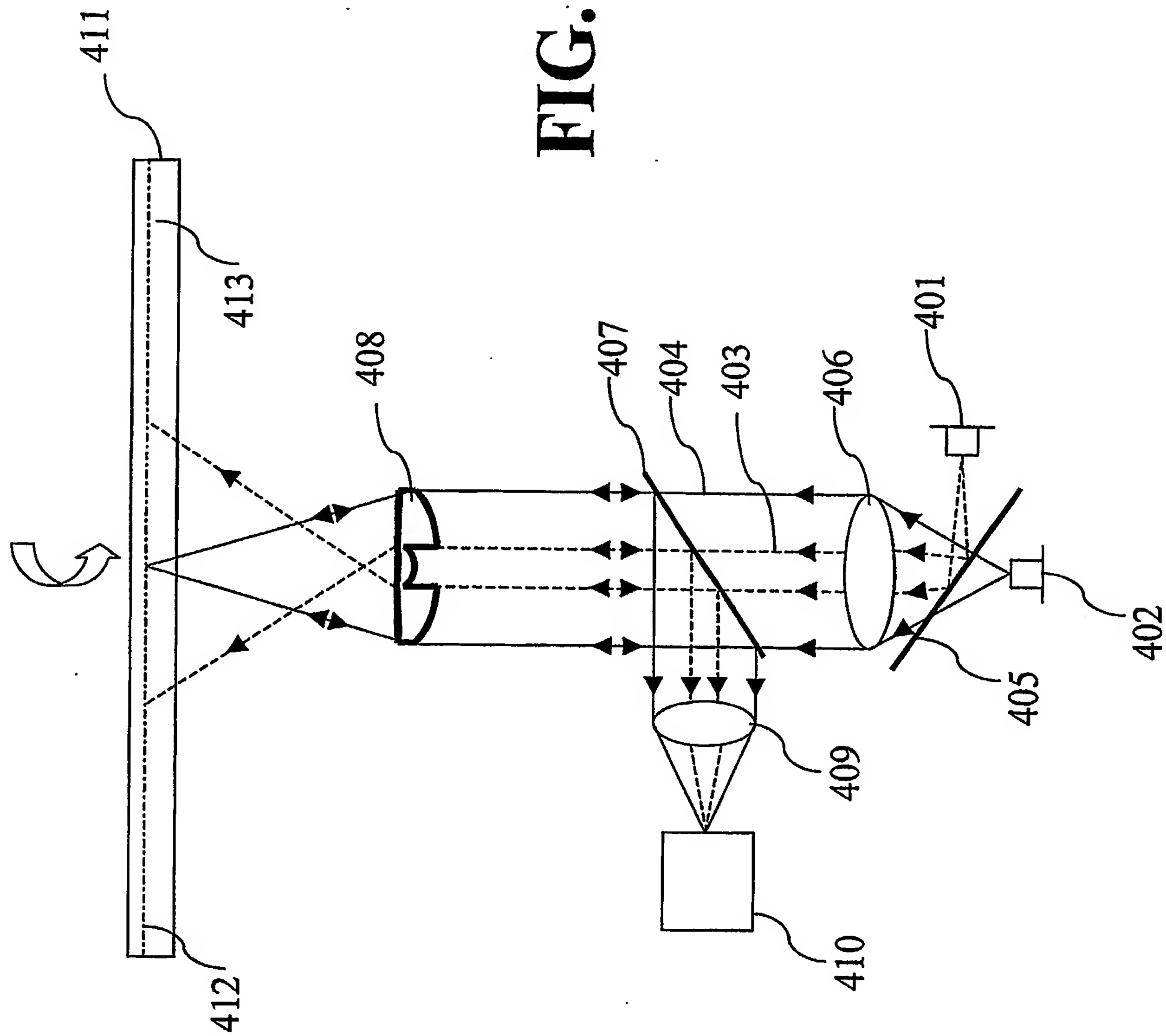


FIG. 4

PCT Application
IB0305376